Space Weather Technical Forecast

Issued on Tuesday, 18 July 2023 at 13:28 Local

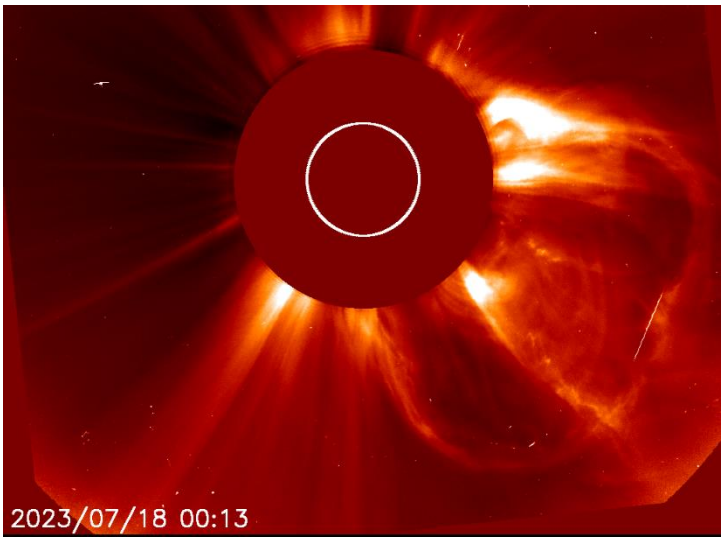
This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout. Chance of G1/G2 (Minor/Moderate Storms) during 20 July.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with several M-class flares observed. The largest was a long duration M5.7 peaking at 18/0005 UTC from AR3363 (located in the southwest quadrant near the horizon). This is has also generated a solar storm with levels surpassing the S2 threshold. There are currently up to nine sunspot regions on the visible disc. Several CMEs (Coronal Mass Ejections) were observed leaving the Sun over the past 24 hours. While most of them are not expected to be Earth-directed, the largest and fastest one has been analysed as potentially giving Earth a glancing blow.

Figure 0: Lasco C2 imagery showing the large CME that followed the M5.7 from AR3363



Solar Wind / Geomagnetic Activity: The solar wind parameters are indicative of the waning influence of a magnetic cloud associated with a CME (the one which arrived on the 16th). The solar wind speed rose to 550km/s for a time but is now on the decline, currently around 510km/s. Density was mostly around average. The total magnetic field (IMF), Bt, has been weak and mostly below 7nT. The north-south component fluctuated between +5 and -6nT but has recently become weaker and mostly orientated northward. Phi angle was consistently negative (towards the Sun). This resulting in Unsettled to Active geomagnetic activity during much of the period although it has become Quiet during the last two intervals.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, became Moderate shortly after the long duration flare emitted by AR3363. The flux rose above the S2 threshold after 18/0200 UTC, reaching a peak of 620pfu at

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18/0615 UTC, and is now declining slowly towards S1 levels. High energy electron flux (greater than 2MeV) has been mostly at background levels but is now on the rise, with a peak of 441pfu observed at 18/1120 UTC. The 24-hour integrated fluence was on a slight rising trend but remains well below the Active (1e8 integrated pfu) threshold. A fluence of 4.6e6 pfu was recorded at 17/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Moderate, with occasional M-class flares and a slight chance of an isolated X-class flare, probably from AR3373 in the northeast.

Solar Wind / Geomagnetic Activity: Current CME influence is expected to gradually ease into 19 July. A fast solar wind may connect with Earth but this is most likely to be masked by the already elevated solar winds originating from the mentioned CME. Another CME was observed leaving the sun after the M5.7 flare that occurred on 18/0000UTC. This may give Earth a glancing blow on the 20th (Day 3), with effect continuing into the 21st (Day 4). Geomagnetic activity is therefore expected to be Quiet to Unsettled on days 1 and 2 (18th & 19th) but largely Active with a chance of G1/G2 (Minor/Moderate) storms intervals on day 3 (20th). Activity returning to Quiet with a chance of Unsettled intervals early on day 4 (21st) as CME effects wane, but confidence is low as it will largely depends on the arrival time of the CME.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S3/Strong Storm threshold for the rest of day 1 (18th), should AR3363 emit another large flare. The risk declines significantly from day 2 (19th) onwards as AR3363 rotates onto the far side, with a daily slight chance of S1. High energy electron flux (greater than 2MeV) is expected to remain moderate on day 1 but may exceed high levels during the diurnal peak on day 2. The electron flux may remain Low or Moderate on day 3 under the influence of the expected CME before becoming High again on day 4, perhaps leading the fluence to breach the Active threshold (1e8 integrated pfu).

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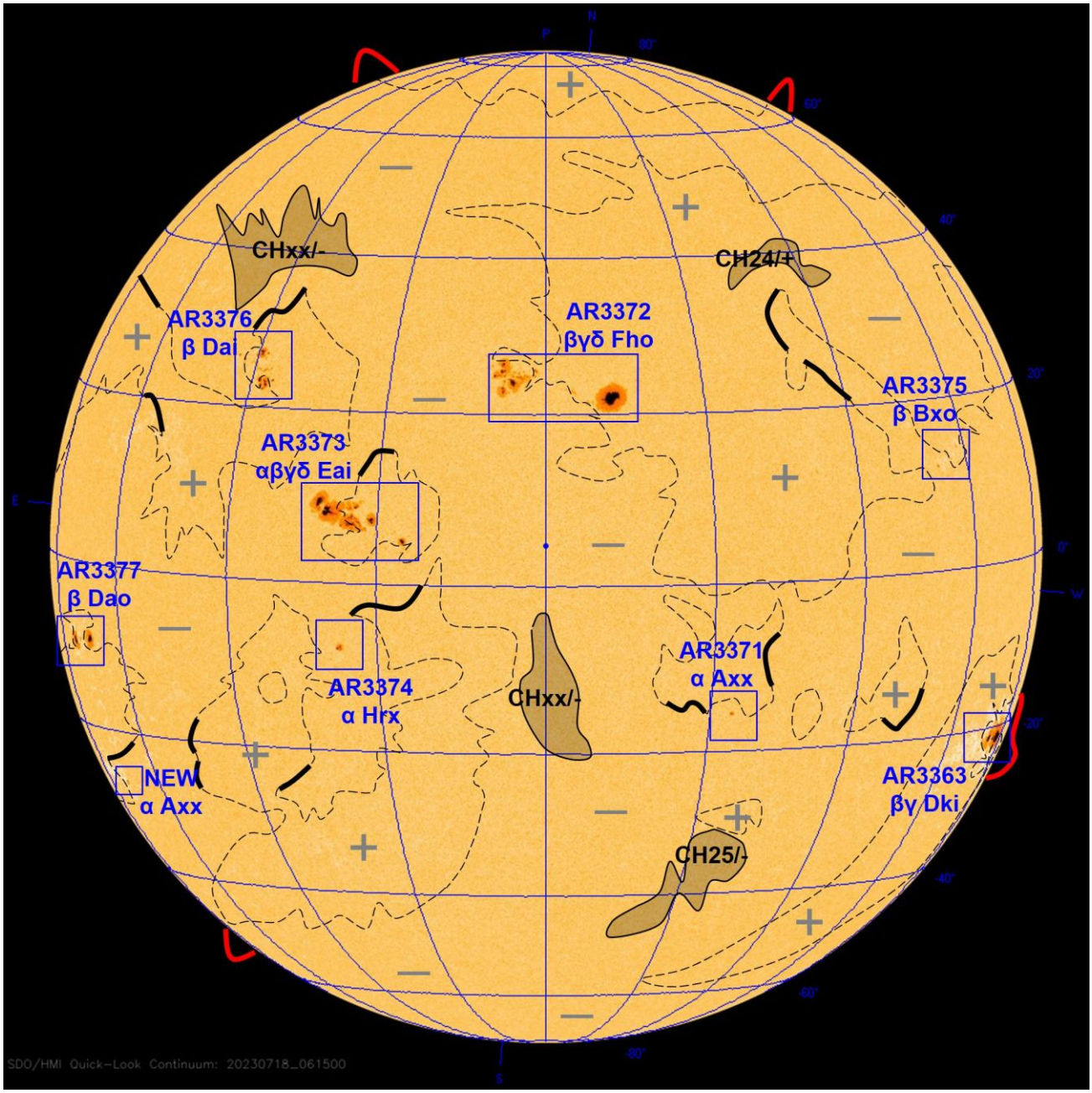
Figure 1. Solar Analysis Valid 18/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Solar winds are now declining towards slightly elevated levels, under the waning influence of the magnetic cloud associated with the CME that arrived late on 16 July. However another CME was observed following the M5.7 flare that occurred around 18/0000 UTC. This was analysed as potentially giving Earth a glancing blow on the 20th (Day 3), with effect continuing into the 21st (Day 4).

The high speed stream from CH24 may connect with Earth by day 2 (19 July) but it is a small feature, with limited enhancements which may be masked by the continuing CME effects.

Geomagnetic activity is therefore expected to be Quiet to Unsettled on days 1 and 2 (18th & 19th) but largely Active with a chance of G1/G2 (Minor/Moderate) storms intervals on day 3 (20th). Activity returning to Quiet with a chance of Unsettled intervals early on day 4 (21st) as CME effects wane, but confidence is low as it will largely depends on the arrival time of the CME.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	40	20
Strong	G3	No	1	1	10	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0145 UTC	Asymmetric full	M5.7 from AR3363	SW quadrant, near the horizon	1630 km/s	20/0600 UTC +/- 6hrs	Bulk of the ejecta passing south of Earth

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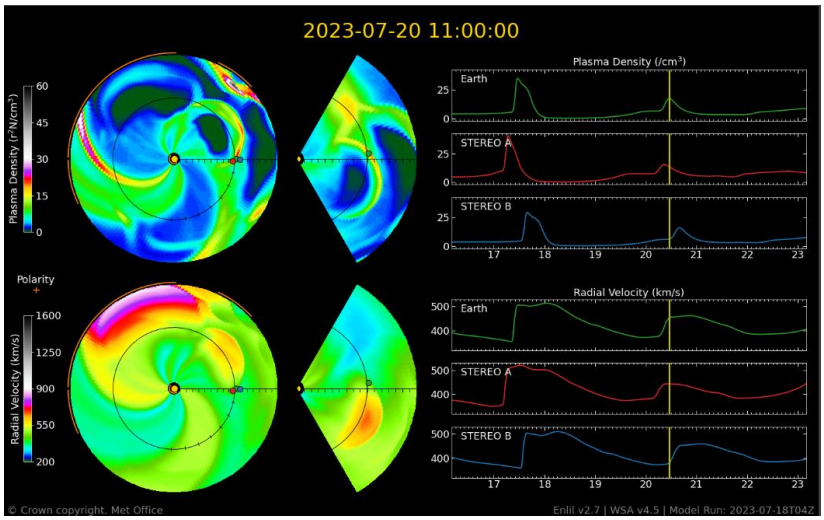
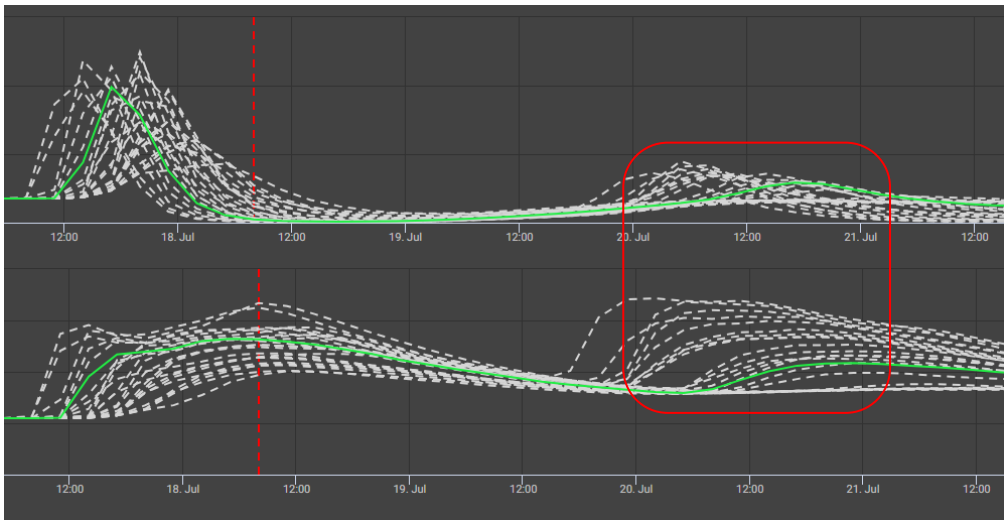
Figure 2: MOSWOC Enlil and ensemble, showing a possible CME arrival on the 20th





Radio Blackouts - X-Ray Flares:

Solar activity was Moderate, with several M-class flares observed. The largest was a long duration M5.7 peaking at 18/0005 UTC from AR3363.

There are currently up to nine sunspot regions on the visible disc. AR3363 is the most active region but its analysis has become increasingly difficult as it is close to the southwest horizon. AR3372 is a large open region, consisting of a simple symmetric leader and a more complex broken trailer that includes occasional, small delta spots. AR3373 grows further especially in its intermediate region with development of mature penumbra. AR3376 is newly numbered in the northeast and has shown intermediate spot emergence, with some penumbra development now evident. It is also north-south magnetically aligned. The newly numbered region AR3377 on the southeast limb appears bi-polar and is looking increasingly more complex. The remaining regions appear stable and relatively small.

Solar activity is expected to remain Moderate, with occasional M-class flares and a slight chance of an isolated X-class flare. AR3363 is almost on the western horizon and should rotate onto the far side in 24 hours or so. However it will be replaced by further large regions currently rotating on the centre disc and the eastern hemisphere, namely AR3372 and AR3373.

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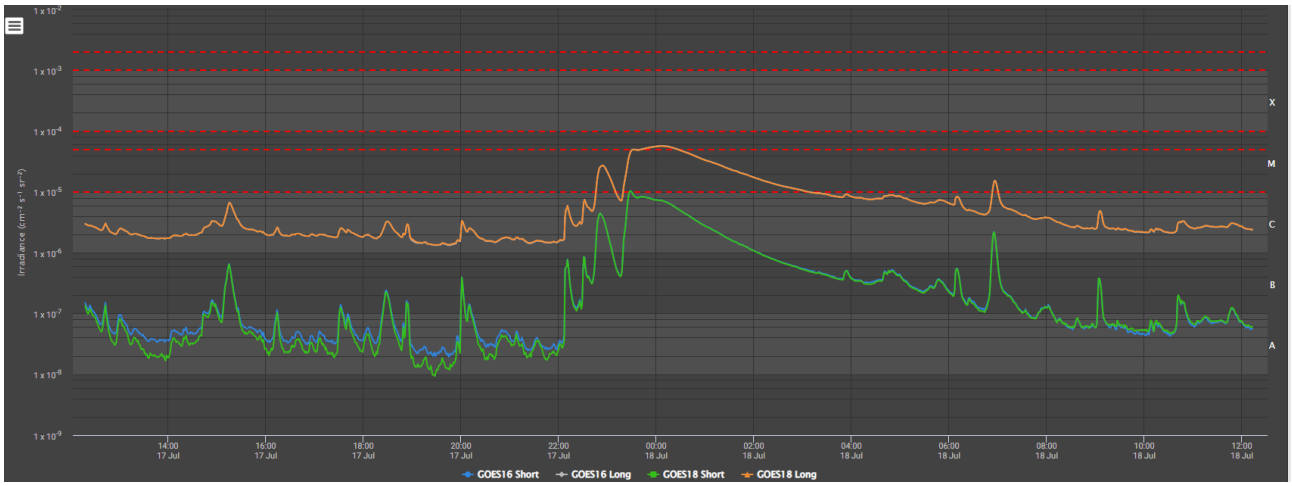
X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	70	70	70
Very Active	R3 to R5 X Class	No	20	15	15	15

Figure 3: Latest X-ray flare activity, as observed by GOES-16



Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16, became enhanced after 18/0000 UTC, shortly after the long duration flare emitted by AR3363. The flux rose above the S2 threshold after 18/0200 UTC, reaching a peak of 620pfu at 18/0615 UTC, and is now declining slowly towards S1 levels.

There is a slight chance of exceeding the S3 threshold today (18th), should AR3363 emit another large flare. The proton flux is expected to slowly decline towards background levels otherwise, but this will take a while and may only happen on day 2 (19th). AR3363 is almost on the western horizon and should rotate onto the far side in 24 hours or so. However it will be replaced by further large regions currently rotating on the centre disc and the eastern hemisphere, maintaining a slight chance of S1 on days 2, 3 and 4.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	100	60	20	20
Very Active	≥ S3 *	No	30	1	1	1

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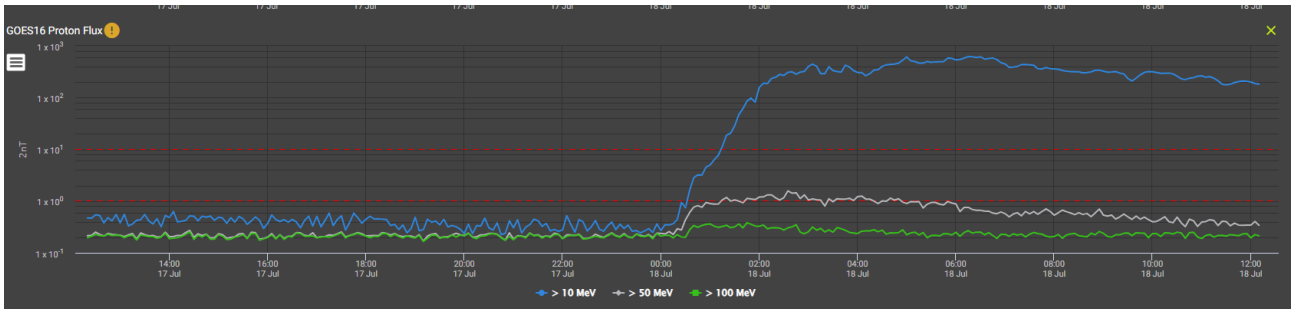
Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	60	20	20
Very Active	**≥ S3 ***	No	30	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest proton flux, as observed by GOES-16



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is on the rise following the CME that arrived on the 16th, the associated magnetic cloud progressively charging the radiation belts. The rise is expected to be modest on day 1 but may exceed high levels during the diurnal peak on day 2. The denser and stronger winds associated with the CME expected to give Earth a glancing blow on day 3 (20th) may reduce temporarily the electron flux but these should replenish the radiation belts on day 4 (21st), leading the fluence to breach the Active threshold (1e8 integrated pfu). Low confidence in the timing though.

The latest REFM output is in reasonable agreement although it is thought to under-estimate the impacts of the coming CME.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	30	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	20

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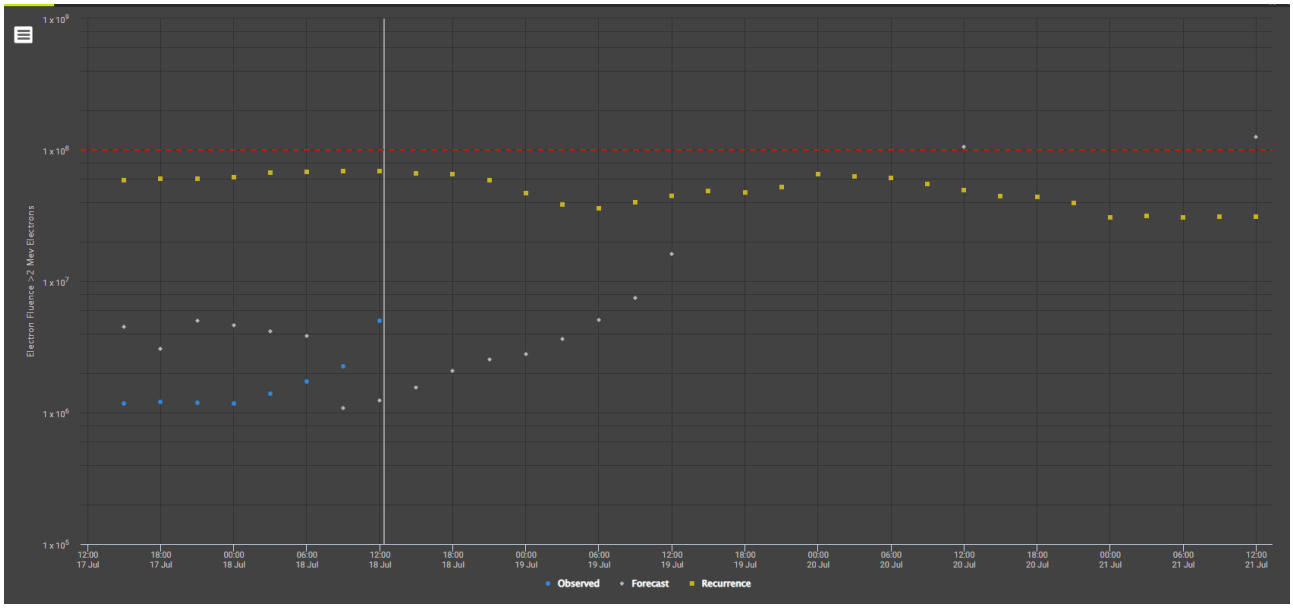
Figure 5: Latest REFM output



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